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UPGRADING THE DOT 6M-2R SHIPPING PACKAGE

by

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DISCLAIMER

UPGRADING THE DOT 6M-2R SHIPPING PACKAGE*

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In early 1980, Federal Regulatory Agencies proposed that the use of DOT Specification Packages for carrying greater than Type A quantities of radionuclides be terminated, and that only certified Type B packaging be used for such shipments (1). The basis for this study is a concern that one package, the DOT 6M, will not meet 1973 IAEA criteria or current 10 CFR 71 regulations. This concern is not with the 6M's overpack, but rather with its containment vessel.

Deficiencies with the present containment vessesl are:

- Degree of containment offered by the vessel not addressed.
- Strength of the vessel not addressed.
- No requirements for leakage tests (either after manufacture, periodic or post loading).
- No QA/QC program.
- No provisions for double containment.
- Lacks low temperature ductility.
- Package thermal capability limited to 10 watts.

At the request of the Department of Energy, a program was initiated at the Savannah River Plant to redesign the 2R containment vessel to meet or exceed current or proposed regulations, and to take into account the requirement for double containment for Pu powders, oxides, or scrap.

New containment vessels were designed and tested under the following criteria:

- The containment vessel would be designed as a pressure vessel, in accordance with an established code (ASME Boiler and Pressure Vessel Code) for services up to 6895 k Pa (1000 psig) and temperatures up to 260°C (500°F).
- The vessel closure would be reusable, of high integrity and use a high temperature O-ring seal. Leakage rate of the closure would be $<10^{-7}$ atm cc/sec under normal and accident conditions.
- Material of construction would be tough and ductile under both the low and high temperatures experienced in transport.
- A QA/QC plan would be generated for the package, with the greater emphasis on significant features of the containment vessel.
- Leakage testing provisions would be designed into the containment vessel closure.

* The information contained in this article was developed during the course of work under Contract DE-AC09-76SR00001 with the U.S. Department of Energy.

The overpack was also revised to contain:

- Provisions to allow loading and unloading without containment vessel removal.
- Ability to add lead shielding [up to 3.2 cm (1-1/4 inch)].
- Increased thermal payload capability.
- Ganging of Celotex® (Celotex Corp.) discs.

The new containment vessel (Figure 1) is designed primarily of Schedule 40 stainless steel pipe. A standard weight pipe cap butt welds to the end of the pipe to form the containment vessel bottom. A smaller diameter section of pipe is tack welded to the pipe cap to form a skirt, to support the vessel vertically. The skirt has a notch, which mates with a key in the overpack to prevent vessel rotation during closure tightening.

Criteria for the containment vessel closure were:

- Lightweight
- Strength equal to that of the Schedule 40 pipe
- Leaktight (<10^{-7}) atm cc/sec air)
- Provisions for leak testing.

A conical closure, with two O-ring seals in series was designed for the vessel. The male cone fits into the female cone of the containment vessel until metal to metal contact is made, thereby eliminating clearance for O-rings extrusion. A leakage test port is provided between the two O-rings and sealed on top of the closure with a commercial high pressure plug.

Viton GLT® (E. I. du Pont de Nemours & Co.) was selected as the O-ring material because of its high and low temperature resistance and its permeability to the test gas (helium). A nut, made of dissimilar material for anti-galling properties, threads into the top of the containment vessel to support the male conical plug. The nut has a square boss for torquing and recessed holes for attachment of a lifting fixture. Upon loosening of the nut, a snap ring on the male cone is engaged with the nut which results in pulling the male cone from its female seat.

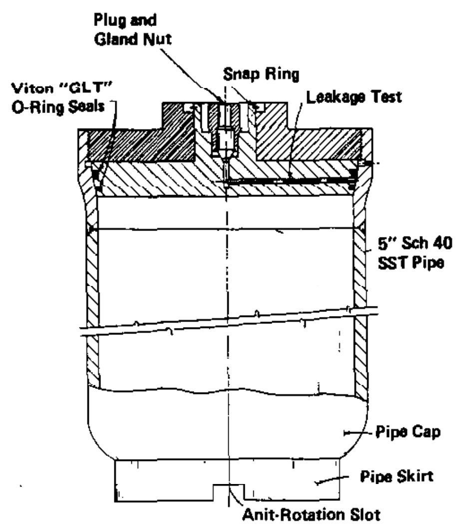

Fig. 1. Specification 2R Primary Containment Vessel

Eight prototype containment vessels were fabricated for evaluation and regulatory testing. A full QA/QC program was performed and recorded on the prototypes. A hole was drilled into the center of the bottom pipe cap on each vessel, and a high pressure pipe (1/4-inch OD) was welded for internal pressurization. The following tests were performed on the prototype vessels:

- Hydrostatic tests at 12,400 k Pa (1800 psig).
- Helium mass spectrometer leakage tests with vessel pressurized to 6895 k Pa (1000 psig) helium and leakage collected in an evacuated envelope. Leakage rate was $<3 \times 10^{-9}$ atm cc/sec air at ambient temperature.
- Thermal testing to seal failure. Vessel pressurized to 6895 k Pa (1000 psig), lost O-ring seal at 418°C (785°F).
- Hydrostatic pressurization to failure. Vessel fails in wall from hoop stress at 55,160 k Pa (8000 psig) (Figure 2).
- Thermal testing at 6895 k Pa (1000 psig) pressure and 315°C (600°F) for 24 hours. Leakage rate before test was equal to rate after test which was $<3 \times 10^{-9}$) atm cc/sec air.

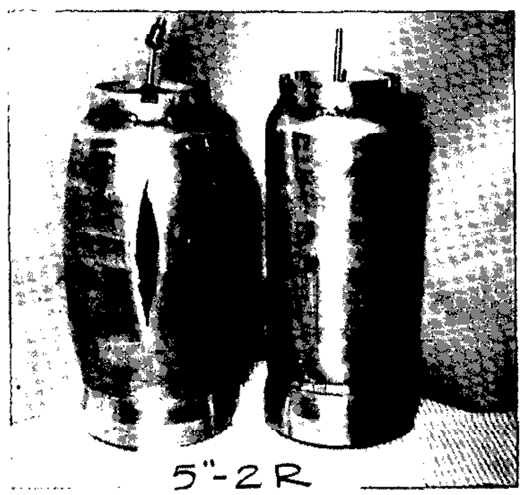

Fig. 2. Specification 2R Containment Vessel after Hydrostatic burst (8,000 psi)

The containment vessels are designed in two different diameters (5-inch and 6-inch size) so that they can be nested together for double containment. They also are designed in different lengths to accommodate different volumes of product.

Four packages passed normal condition and hypothetical accident testing satisfactorily using these containment vessels (2). The packages are described in Table 1.

The SP 9965 package (Figures 3 and 4) consists of a 30-gallon galvanized, removable top drum (DOT 17C) with 15.24 cm (6 inches) of Celotex® insulation between the drum and the single containment vessel. Two aluminum plates are counterbored into the insulation to act as bearing plates. A square key is bolted to the upper surface of the bottom bearing plate to prevent containment vessel rotation. The Celotex® discs are bolted together and attached to nylon straps to aid disassembly.

The SP 9966 package is identical to the SP 9965 with the exception that two containment vessels are nested together to form a double containment assembly which results in reducing the Celotex® thickness to 14 cm (5-1/2 inches).

TABLE 1
COMPARISON OF MODIFIED 6M PACKAGES

Certificate of Compliance No.	Degree of Containment	Overpack Size, gal	Containment Vessel Cavity Size, dia x length cm (inches)	Auxiliary Shielding, cm lead	Weight, kg (lbs)
SP 9965	Single	30	12.7 x 28 (5 x 11)	0.5	68 (150)
SP 9966	Double	30	12.7 x 28 (5 x 11)	None	107 (236)
SP 9967	Double	55	12.7 x 28 (5 x 11)	3.18	284 (627)
SP 9968	Double	35	12.7 x 18 (5 x 16)	1.3	184 (406)

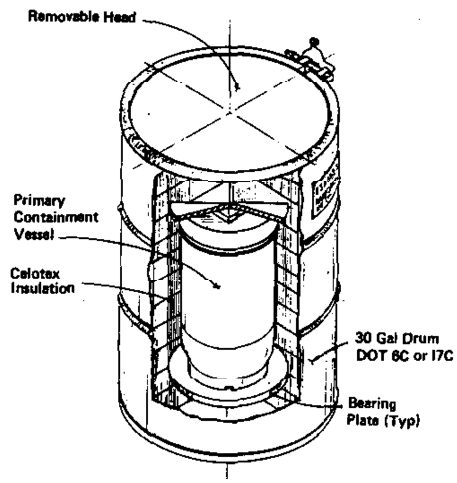

Fig. 3. SP 9965 Package

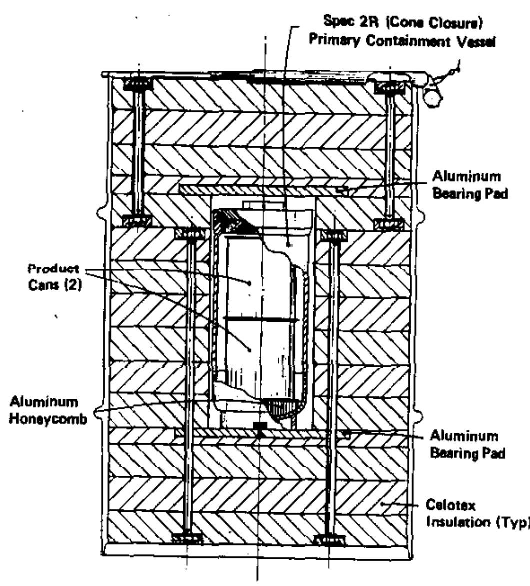

Fig. 4. SP 9965 Assembly

The SP 9967 and SP 9968 packages (Figure 5) feature double containment assemblies with optional lead shielding [up to 3.2 cm (1-1/4 inches)]. Two different lengths of containment vessels are featured thereby requiring two different size drums (35 and 55 gallons).

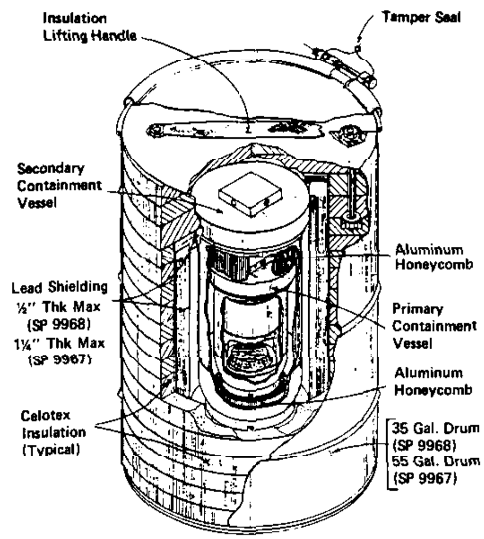

Fig. 5. SP 9967 and SP 9968 Packages

The four packages were submitted to normal condition thermal tests and hypothetical accident testing. Each package was placed in an environmental chamber and heated to an atmospheric temperature of 65°C (150 to 155°F) which represents 55°C (130°F) plus full sunlight. Internal electrical heaters embedded in the containment vessels were energized and all interface temperatures were recorded. Drum position was also varied from vertical to horizontal. The heat load was varied from 0 to 30 watts. It was found that the four packages could safely dissipate 30 watts of heat without exceeding threshold damage temperature to the Celotex® (150°C).

The hypothetical accident tests, as described in 10 CFR Appendix B, were performed on the four packages. Drops were performed with the drum axis vertical and closure down so as to cause the greatest damage to the nested containment vessel assembly, and also with the drum centerline at 30° angle with the vertical, in an effort to pop the drum top off (Figure 6). Damage to all packages was insignificant and is recorded in Safety Analysis Report-Packages (2).

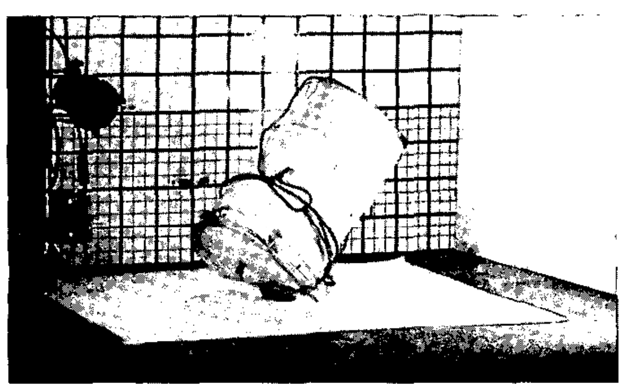

Fig. 6. SP 9966 During 30 Feet Free Drop

Following free drop and the puncture tests, the damaged packages were submitted to thermal tests. Two furnaces were used, one to preheat the package up to its normal operating temperatures in an environment of 38°C (100°F), which resulted in a containment vessel temperature of 121°C (250°F), and the second furnace to expose the package to an environment of 802°C (1475°F). The second furnace was heated to 927°C (1700°F) and held for 2 hours in an effort to minimize time to return to 802°C (1475°F) after door opening and package insertion. When the packages were exposed to temperatures above 802°C (1475°F) for 30 minutes, the Celotex® insulation evolved flammable gases from the binder cements and these gases burst into flame upon exiting the drum (Figure 7) through the required vent holes. When the drum assemblies were removed from the furnace, these flames were self-extinguishing within a period of 2 minutes. The packages were allowed to air cool for 24 hours. Upon disassembly, it was found that the insulation was badly decomposed for the first 5 cm (2 inches), but had performed its intended function by limiting the increase in temperature of the containment vessel to less than 10°C (50°F) which occurred 7 hours after the drum was removed from the furnace. Undamaged packages were submitted to the 50-foot water immersion tests (Figure 8) with insignificant damage.

Fig. 7. SP 9966 Package During Thermal Test

Fig. 8. SP 9966 Package Prior to 50 Feet Water Immersion Test

The Safety Analysis Report for Packages is presently being reviewed and these packages are scheduled to go into service in late 1983.

1. Memo to Richard R. Rawl, U.S. Department of Trnasportation from Charles E. MacDonald, Chief, Transportation Certification Branch, U.S. Nuclear Regulatory Commission (January 16, 1980).

2. G. G. Chalfant, Safety Analysis Report-Packages, USA/9965/BLF(DOE-SR) through and including USA/9968/BLF(DOE-SR).